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Growth and Movement of Homarus Americanus on the Outer Coast of Nova Scotia

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GROWTH AND MOVEMENTS OF *HOMARUS AMERICANUS* ON THE OUTER COAST OF NOVA SCOTIA

by

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ABSTRACT

Miller, R.J., R.E. Duggan, D.G. Robinson, and Z. Zheng. 1989. Growth and movement of Homarus americanus on the outer coast of Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 1716: v + 17 p.

Lobsters with sphyrion tags were released at one location in both 1978 and 1979 and at seven locations in 1982, all on the outer coast of Nova Scotia. Most lobsters were within the size range of 81-90 mm carapace length at release. Females increased an average 14.5% and males an average 15.2% of carapace length per molt, equivalent to 47% and 55% weight increments, respectively. Nine other studies carried out in Atlantic Canada and Maine, U.S.A. reported growth increments similar to these. Among 698 lobsters recaptured in this study after 1-6 years at liberty, only three were recovered >12 km from their release point. Other published reports representing many areas in Atlantic Canada and Maine show that recruit sized lobsters are usually recovered within <12 km of release sites.

RÉSUMÉ

Miller, R.J., R.E. Duggan, D.G. Robinson, and Z. Zheng. 1989. Growth and movement of Homarus americanus on the outer coast of Nova Scotia. Can. Tech. Rep. Fish. Aquat. Sci. 1716: v + 17 p.

On a remis à l'eau au large de la côte de la Nouvelle-Écosse - en un endroit en 1978 et 1979 et en sept endroits en 1982 - des homards munis d'une étiquette malléolaire. La longueur de la carapace de ces homards se situait dans la plupart des cas entre 81 et 90 mm au moment de la remise à l'eau. Les caparaces des mâles et celles des femelles se sont allongées respectivement de 14,5 p. 100 et de 15,2 p. 100 en moyenne à chaque mue, ce qui équivaut à une croissance pondérale respective de 47 p. 100 et de 55 p. 100. Neuf autres études réalisées dans la région canadienne de l'Atlantique et dans le Maine par des Américains ont permis de constater une croissance comparable. On a recapturé, au bout de un à six ans de liberté, 698 des homards étiquetés dans le cadre de l'étude décrite ici; or, seuls trois d'entre eux ont été repris à plus de 12 km de l'endroit de leur mise à l'eau. Comme le révèlent d'autres études effectuées en divers endroits de la région canadienne de l'Atlantique et du Maine, les homards qui ont atteint la taille de recrutement sont habituellement repris dans un rayon de 10 km de leur point de remise à l'eau.

INTRODUCTION

Advice to increase the recruit size of American lobsters may be the advice most frequently given by lobster biologists to fishermen and fisheries managers (Anon. 1977; Miller et al. 1987). These clients often respond with three key questions. If we let lobsters grow larger will they move away from our fishing grounds? How quickly will they grow from the old to the new legal size? How do you know they will not die of natural causes before reaching the larger size? The first two questions are addressed in this report.

Tagged lobsters were released in 1978 and 1979 at one location each, and in 1982 at seven locations, all on the outer (Atlantic) coast of Nova Scotia. The 1978 and 1979 releases were designed to show growth and movement of a large range of sizes, whereas the 1982 releases were intended to demonstrate to fishermen the amount of movement and growth of the recruit molt class only. The recruit molt class is the size group within one molt larger than minimum legal size, ∿70-79 mm CL for eastern Cape Breton ∿81-93 mm CL for the remainder of the Scotia-Fundy Region.

Because the interests of fishermen are often specific to their own fishing area, published studies of growth and movement are reviewed for several areas of Atlantic Canada and Maine, U.S.A. (Fig. 1) as a reference source for biologists presenting the benefits of increased recruit size. High growth rates and restricted migration of the recruit molt class were recurrent results.

METHODS

The sphyrion tag was chosen because it can be retained through a molt (Scarratt and Elson 1965). Cooper (1970) reported 88% tag retention by lobsters which molted once, and Duggan and Pringle (1988) reported 73% tag retention by lobsters at liberty for about 7 months, but which had not molted. After 1 year at liberty Ennis (1986) observed 64% retention by lobsters which molted and 76% retention by those which had not. In the Cooper and Ennis studies tagged lobsters were also marked by cutting off small pieces of the exoskeleton; in the Duggan and Pringle study a second (carapace strap) tag was used.

In 1978 lobsters were released at three areas near New Harbour (Fig. 2), 9-28 m depth at each. The lobsters were caught in baited traps, tagged on board the fishing vessel, and released within a few minutes at the location of capture. This procedure was repeated at 3 week intervals on four occasions from July 25 to September 29. Data from recaptures which occurred during the tagging operation were not used. All subsequent recaptures were made by the fishery. When the recaptured lobster as well as the tag were held for a biologist, size and growth could be measured. When only recapture location was provided, movement could be calculated. Data on movement were collected during the May-June fishing season of the following six years. Growth per molt was analyzed only from recaptures in the spring of 1979. Percentage molting was not included because tagging was carried out during the 1978 molting season and it was not known which lobsters had molted before they were tagged.

Releases in 1979 were from 4-13 June at four locations in Port Mouton (Fig. 3). As above, lobsters were trapped, tagged aboard the fishing boat, and released near the area of capture. Recaptures came from the fishery during the following three seasons, lasting from late November to late May. These lobsters were at large for at least one molting season.

In the 1982 studies lobsters were purchased at the wharf near the end of the spring fishing season. Releases were made by the fisherman supplying the lobsters onto his fishing grounds. Recaptures were recorded for the next fishing season after the lobsters had been at large for one molting period. These seasons were late November to late May in Port Mouton, and approximately 60 of the 90 days between mid-April and mid-July in all other locations. The type of data collected at each station is summarized in Table 1.

RESULTS

GROWTH

Recoveries were low (6-16%) from all locations because not all tags were recovered from fishermen and inexperienced staff applying tags may have caused high tag loss or high lobster mortality.

Regressions for postmolt (CL_2) vs. premolt (CL_1) carapace length in mm from the 1978 tagging at New Harbour were:

male	$CL_2 = 1.05\ CL_1 + 8.10$	premolt range: 71-109 mm CL
female	$CL_2 = 1.06\ CL_1 + 6.65$	premolt range: 72-109 mm CL

It is apparent from the data summary in the following text table that molting was nearly complete by late September.

Tagging date	Number recaptured in spring 1979	Number increased in size
July 25-28	53	37
Aug. 15-18	48	40
Sept. 6-9	70	14
Sept.26-29	91	3

Postmolt vs. premolt regressions from the 1979 releases at Port Mouton were:

male	$CL_2 = 1.00\ CL_1 + 12.70$	range 68-92 mm CL
female	$CL_2 = 1.14\ CL_1 + 0.29$	range 64-92 mm CL

All but 3 of 31 males and all of 34 females molted.

The premolt size of lobsters which were recovered, the number that were measured at recovery, the percentage growth per molt, and percentage of skip-molters are summarized for each area in Table 2. Postmolt-premolt regression equations were not calculated for the 1982 releases because the size range of tagged lobster was only about 10 mm CL. The size of lobsters tagged at Gabarus is lowest because the minimum legal size is 70 mm vs. 81 mm in the other areas. The mean percentage growth per molt is in quite good agreement among areas for males, 14.5-16.0%, and has only a little larger range for females, 12.4-15.8%. Although statistical differences among areas exist, given the low returns and other uncertainties associated with the studies, we could not safely infer population differences. The weighted averages of growth over all areas for lobsters which molted were 15.2% for males and 14.5% for females.

Of all males recovered from the 1982 releases, only 7% skipmolted, and most of these were from Port Mouton (Table 2). Only nonovigerous females were tagged in 1982. Seven percent of these skipmolted and remained nonovigerous, a further 6% skipmolted and became ovigerous. Very few females molt and become ovigerous in the same year (Aiken and Waddy 1980). Because ovigerous females cannot be sold legally, some caught may not have been landed and the percentage ovigerous may have been underestimated. The likelihood of females of the sizes tagged becoming ovigerous differs among areas. This will be considered in the Discussion.

MOVEMENT

Recaptures of the 1978 releases at New Harbour were in or near the release zone (Table 3, Fig. 2). Only 9% were captured outside the release zone (areas 2, 3, and 4), and these were predominantly from adjacent areas, i.e. from area 2 to 1 and 4 to 5. Movement from the release zone was no greater for lobsters at large for 2-6 years (23/262=9%, 1980-84 recaptures) than for those at large for only 1 year (10/96=10%, 1979 recaptures). The greatest easterly movement was about 8 km by two lobsters. The greatest westerly movement was about 25 km for one lobster and 500 km to Browns Bank for another. Only these four lobsters were captured off the grounds of New Harbour fishermen. Equal numbers moved out of the release zone to the east and west (Table 3). One might expect that an equal number also moved into the release zone.

From the 1982 releases at New Harbour, 21 were recaptured within 2 km of release, two between 2 and 5 km, and the final two 7 km from the release. Among 77 recaptures from releases at the nearby sites of Berry Head, White Head, and Dover, 63 were within 2 km and the remainder within 5 km of release. None of these lobsters moved off the community's fishing ground where they were released.

Port Mouton releases traveled slightly farther than those from the New Harbour area. From the 1979 release 56 were recaptured less than 2 km away, 49 between 2 and 5 km, 5 between 5 and 10 km, and one 210 km. From the 1982 release, 52 of 75 recoveries were within 5 km and the remainder within 12 km. Two of these were caught by fishermen from a nearby harbour on grounds shared

with Port Mouton fishermen. Even though release locations were different in 1979 and 1982, most recoveries from both releases were within 2 km northwest to west-northwest of the northern end of Mouton Island (Fig. 3).

Insufficient recovery locations were provided to discuss movement for the remaining 1982 releases.

DISCUSSION

GROWTH

If lobsters in the smallest molt class now taken by the fishery were left on the grounds, most would increase about 50% in weight during the summer between fishing seasons. Using the length-weight regressions from Campbell (1985) and, growth per molt of 15.2% CL for males and 14.5% CL for females as presented above, males would increase in weight by 55% and females by 47%. Only 7% of males and 6% of nonovigerous females failed to molt. Of course, natural mortality is also a consideration in measuring the benefit of increased recruit size. Although presumed to be of the order of 10% (Thomas 1973), it was not a topic of this investigation.

The observation that 6% of females do not molt because they become ovigerous is probably too low a value for all but Ostrea Lake and Port Mouton. Studies on size at maturity carried out in the tag release and nearby locations (Campbell and Robinson 1983; Watson 1988; Watson and Miller, unpub.) indicate that 10-80% will extrude eggs if they survive the first year at legal size (Table 4). Table 4 also shows that increasing the minimum size by one molt class would give many more females the opportunity to produce eggs before being subjected to the fishery.

A review of growth per molt estimates for several Canadian inshore locations shows reasonable agreement, especially considering the geographic separation, small sample sizes in some cases, and the range of size at maturity. Tables 2 and 5 show growth per molt within 12.8 to 16.2% for males, and 11.2 to 16.9% for females. Results for Maine inshore waters are similar (Table 5).

MOVEMENT

Among 698 lobsters recaptured in this study after 1-6 years at liberty, only 3 were recovered more than 12 km from their release point. Only 6 were recaptured on fishing grounds of a community other than the grounds where they were released. Therefore, increasing the minimum size by one molt class should not result in this group of 81-93 mm CL lobsters (70-80 mm CL in Gabarus) moving to other fishing grounds.

The following review of several tagging studies carried out in the nearshore waters of Atlantic Canada and Maine, U.S.A. adds strong support to the

view that >90% of lobsters near the minimum legal size move only short distances. Place names can be located in Figure 1.

Newfoundland: Templeman (1940) attached metal tags to the telsons of lobsters that had recently molted or were carrying eggs, and were ≥80 mm CL. Tags were applied in the autumn and recovered by the fishery 9-10 months later before the next molting season. The 225 recaptured in Bay St.George and the 23 recaptured in Port au Port Bay moved an average 3.6 and 9 km respectively.

In Bonavista Bay divers counted lobsters almost monthly for 2.5 years on a rocky slope ranging from 5-28 m deep and 50-100 m wide (Ennis 1984). Maximum lobster size was 107 mm CL, but the minimum was not given. Mean depth of occurrence ranged from 9.5 m during June-August to 14.1 m during December-March. From these observations and a tagging study Ennis concluded that horizontal movements were slight.

Gulf of St. Lawrence: Templeman (1935) clipped metal tags to the telsons of lobsters 74-116 mm CL. From six release sites in the Magdalen Islands 148 lobsters moved an average of 7 km, and from two release sites in Egmont Bay, Prince Edward Island 74 lobsters moved an average 9.5 km. From all 8 sites 9% moved >16 km. Time at large was 9-12 months.

Also in Egmont Bay, P.E.I., 253 mostly mature females 76-97 mm CL, moved an average 13.5 km after 10-12 months at liberty (Wilder 1963). Nineteen moved more than 24 km. Large numbers were released in a single location. Had releases been at the area of capture, movement would probably have been less.

Maynard and Chaisson (1986 a,b) released lobsters at one location in western and two in eastern Northumberland Strait. After 7-24 months at large 60% of 613 recaptures in Egmont Bay had moved more than 10 km, and 23% had moved more than 25 km. This agrees with the relatively long distance movements also reported by Wilder (1963) for the same location. However, at Beach Point and Margaree in eastern Northumberland Strait, 81% (n=380) and 93% (n=190) respectively were recovered <10 km from release points after 9-11 months at large. Lobster sizes were not given.

Wilder (1974) reported recoveries of 33,000 lobsters tagged near Tignish and Miminegash, P.E.I. These were released just prior to the season during several years in order to measure exploitation rates. Although they were at large for an average of only a few weeks, none of these many recoveries traveled between the two fishing grounds located about 18 km apart.

In the head of Chaleur Bay, Marcotte (quoted in Stasko 1980) recovered 188 lobsters at large for 8-9 months. One hundred and seventy five moved less than 12 km.

Nova Scotia: Recoveries on the Forchu-Gabarus and L'Archeveque fishing grounds totaled 15,000 over several years (Wilder 1974). Although most were

recovered within weeks of release, 2,000 were at large for at least one year. None of the recoveries had traveled between the two grounds separated by only 7 km.

During April-June, 1987 near Clam Bay, fishermen recovered 611 sphyrion tagged lobsters (60-115 mm CL) released the previous October (Duggan and Pringle 1988). Only four were recovered >10 km from the release points.

In three areas near Seal Island, 20 km off southwest Nova Scotia, 214 lobsters were recaptured after an average time at liberty of 1 year (Campbell and Stasko 1985). One-third of those <95 mm CL at release had moved >18.5 km, whereas 51% of those ≥95 mm CL had moved >18.5 km. Twenty-three moved at least 50 km from release. Although a small study, these results suggest substantial lobster movement.

Annual tagging was carried out in Port Maitland for many years to estimate exploitation rate (Campbell 1982). Carapace strap tags were used from 1944-1968 and sphyrion tags from 1978-1980. The size range was 79-140 mm CL with a mean of 87 mm CL. Lobsters were released over a 111 km^2 fishing ground during November, just before the late November to late May season; mean time at large was 5 months. Of the 14,270 recoveries, 81% were from the release area and a further 15% were within 18 km of the release area.

Bay of Fundy: Sphyrion tagged lobsters were released in large numbers from three sites during July-September 1977-80 (Campbell and Stasko 1986). As summarized in Table 6, sexually mature lobsters moved further than immatures, and mature females moved further than mature males. Although the immatures did not move an unusual amount, the mature lobsters moved considerably further than lobsters in any other study reviewed.

Campbell (1986) released and recaptured berried females (85-188 mm CL) year-round near Grand Manan. The 1987 recaptures were at liberty for an average of 65d and were recovered at an average distance of 7.7 km; 76% of distances were <15 km. During July-September they were found <20 m deep, whereas from November-June they were 100-200 m deep.

Maine: Near Boothbay Harbour divers counted lobsters on 540 m^2 of bottom at 6-12 m and 18-24 m depth at each of two locations at monthly intervals for two years (Cooper et al. 1975). Lobster sizes were mostly between 20 and 80 mm CL. Because sex ratios, mean sizes, and densities showed little change with season or depth, the authors concluded that the lobsters did not make seasonal migrations.

Krouse (1981) recovered 2,187 lobsters from releases near Kennebunkport, Boothbay Harbor, and Jonesport, Maine. Mean distances from release to capture location were 5, 8, and 5 km respectively. The large releases at a single locations would probably exaggerate travel compared to native animals, whereas >90% recapture within 4 months favored short distances.

Cooper (1970) recovered a total 1,755 lobsters tagged either by sphyrion tags, dart tags in the elbow (carpus), or marked by branding. Ninety-nine percent were recovered within the 40 km^2 release area around Monhegan Island. Seventy-eight percent of the recoveries were within 6 months, but 15% were after 1 year.

Conclusion: The weight of evidence from many areas over many years of study is that recruit sized lobsters moved less than 12 km. Larger sexually mature lobsters released from two areas in the upper Bay of Fundy and near Seal Island off southwest Nova Scotia were the only groups to be recovered substantially further than 12 km from release sites. Lobsters released from Grand Manan at the mouth of the Bay of Fundy and in Egmont Bay, P.E.I. commonly moved 10-20 km between release and recapture.

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Table 1 - Type of data obtained for each location and release date.

Location	Release Date	Growth per molt	Percentage molting	Movement
New Harbour	25/VII-29/IX, 1978	X		X
New Harbour, Berrys Head, White Head Dover Harbour	23-24/VI, 1982	X	X	X
Port Mouton	4-13/VII, 1979	X	X	X
	31/V, 1982	X	X	X
Gabarus	7-20/VI, 1982	X	X	
Forchu	14-20/VI, 1982	X	X	
Rocky Bay	17-29/VI, 1982	X	X	
Jerseyman's Is.	16/VI, 1982	X	X	
Ostrea Lake, Owl's Head	31/V, 1982	X	X	

Table 2 - Growth per molt, sample sizes and the number of lobsters which skip-molted for each area and sex.

Location	Year	Male					Female				
		Premolt size (mm)		Growth/molt	Skip-molters		Premolt size (mm)		Growth/molt	Skip-molters	
		Mean ± S	N	Mean % ± S	N	(%)	Mean ± S	N	Mean % ± S	Non-ovigerous N (%)	Ovigerous N (%)
Gabarus	1982	75.9 ± 4.0	25	16.0 ± 2.9	1	(4)	75.8 ± 2.9	28	13.4 ± 4.2	1 (4)	0 (0)
Forchu	1982	86.0 ± 2.5	16	14.5 ± 2.0	1	(6)	85.0 ± 3.0	15	12.4 ± 1.8	2 (13)	3 (20)
Rocky Bay	1982	83.6 ± 1.8	13	15.0 ± 5.3	0	(0)	83.0 ± 1.9	15	15.0 ± 4.0	0 (0)	1 (7)
Jerseyman's I.	1982	83.5 ± 2.8	33	16.1 ± 3.1	1	(3)	82.4 ± 1.9	31	15.0 ± 4.0	0 (0)	3 (10)
New Harbour	1978	86.7 ± 10.8	44	14.5[b]	a	-	87.7 ± 9.2	64	13.8[b]	a -	a -
New Harbour, etc.	1982	85.8 ± 3.2	59	15.8 ± 2.9	1	(2)	84.6 ± 3.0	64	15.5 ± 2.8	8 (13)	3 (5)
Ostrea Lake, etc.	1982	85.8 ± 4.2	11	15.2 ± 3.3	0	(0)	85.2 ± 4.0	12	15.8 ± 1.9	0 (0)	0 (0)
Port Mouton	1979	78.7 ± 5.6	31	14.9[b]	3	(10)	77.1 ± 5.9	34[b]	14.7[b]	0	0
Port Mouton	1982	84.0 ± 2.2	39	14.6 ± 3.3	9	(23)	85.3 ± 3.1	31	14.4 ± 3.5	2 (6)	2 (6)

[a]Cannot be calculated.
[b]Based on postmolt CL vs. premolt CL regression, calculated for premolt CL of 85 mm.

Table 3 - Release and recapture locations for 1978 tagging at New Harbour. (See Fig. 2 for area locations).

		Area of Recapture						
		1	2	3	4	5	6	7
Area of release	2	15	75	15	6	0	1	0
	3	1	10	27	9	1	1	0
	4	2	22	97	64	10	2	0

Table 4 - Percentage of females which are mature in the first molt class below and above minimum legal size at the present minimum legal size.

Location	Size range of successive molt classes (mm CL) 62-70	71-80	81-93
Gabarus	<10	40	
Forchu		40	80
Rocky Bay		22	62
Jerseyman's Island		22	62
New Harbour		12	44
Ostrea Lake		3	10
Port Mouton		3	10

Table 5 - Review of lobster growth per molt for Canadian and Maine studies. (N-no. lobsters, CL_1-premolt carapace length, CL_2-postmolt carapace length).

Location	Sex	N	Range in CL (mm)	Regression equation	Increase (%) at 85 mm CL	Source
Bonavista Bay, Nfld.	M	54	52-90	$CL_2 = 1.124\ CL_1 + 2.352$	15.2	Ennis (1971)
	F	56	57-89	$CL_2 = 1.001\ CL_1 + 9.735$	11.6	
Placentia Bay, Nfld.	M	44	50-92	$CL_2 = 1.184\ CL_1 - 2.348$	15.6	Ennis (1978)
	F	94	56-106	$CL_2 = 1.008\ CL_1 + 8.878$	11.2	
Magdalen Islands, Quebec	M	99	65-108	$CL_2 = 1.15\ CL_1 + 0.27$	14.7	Dubé (1986)
	F	69	60-85	$CL_2 = 1.00\ CL_1 + 9.67$	11.4	
Egmont Bay, P.E.I.	M	466	55-75	$CL_2 = 1.051\ CL_1 + 8.73$	15.4	Wilder (1963)
	F	404	55-75	$CL_2 = 1.004\ CL_1 + 10.52$	12.8	
	M	29	63-83	$CL_2 = 0.969\ CL_1 + 15.09$	14.7	Conan et al. (1982)
Beach Point, P.E.I.	M	25	60-90	$CL_2 = 1.086\ CL_1 + 4.34$	13.7	Conan et al. (1982)
Miminegash, P.E.I.	M	21	64-80	Not given	13.7[a]	Scarratt (1970)
	F	51	64-85	Not given	14.3[a]	
New Harbour, N.S.	M	44	71-109	$CL_2 = 1.05\ CL_1 + 8.10$	14.5	This study
	F	64	72-109	$CL_2 = 1.06\ CL_1 + 6.65$	13.8	
Port Mouton, N.S.	M	31	68-92	$CL_2 = 1.00\ CL_1 + 12.70$	14.9	This study
	F	34	64-92	$CL_2 = 1.14\ CL_1 + 0.29$	14.3	
Port Maitland, N.S.	M	284	65-96	$CL_2 = 1.083\ CL_1 + 3.865$	12.8	Campbell (1983[a])
1948, 1960, 1963, 1967	F	346	65-96	$CL_2 = 1.057\ CL_1 + 5.592$	12.3	
1979	M	20	70-85	$CL_2 = 1.111\ CL_1 + 4.361$	16.2	
	F	21	70-85	$CL_2 = 1.136\ CL_1 + 2.818$	16.9	
Bay of Fundy	M	360	60-160	$CL_2 = 1.04\ CL_1 + 10.10$	15.9	Campbell (1983[b])
	F	329	60-94	$CL_2 = 1.04\ CL_1 + 9.60$	15.3	
	F	159	95-150	$CL_2 = 0.95\ CL_1 + 18.01$	13.0[b]	
Boothbay Harbour, Me.	M&F	25	81-96	$CL_2 = 1.24\ CL_1 - 9.45$	12.9	Krouse (1981)
Jonesport, Me.	M&F	23	81-95	$CL_2 = 0.92\ CL_1 + 20.01$	15.5	Krouse (1981)
Monhegan I., Me.	M&F	84	81-110	Not given	12.2[c]	Cooper (1970)

[a]Growth increment at 70 mm CL.
[b]Growth increment at 100 mm CL.
[c]Growth increment at 90 mm CL.

Table 6 - Movement of tagged lobsters from three locations in the Bay of Fundy. Data from Campbell and Stasko (1986).

Sexual Maturity	Release area	Sex	Number recaptured	Mean mos. at liberty	Mean distance (km)	% moved <18 km
Immature 40-95 mm CL	all 3 combined	M	1562	5	6	89
		F	1596	6	7	
Mature 96-203 mm CL	Alma	M	306	10	20	51
		F	309	12	21	29
	Chance Hbr.	M	446	8	15	58
		F	299	9	27	35
	Grand Manan	M	294	11	12	70
		F	386	14	13	70

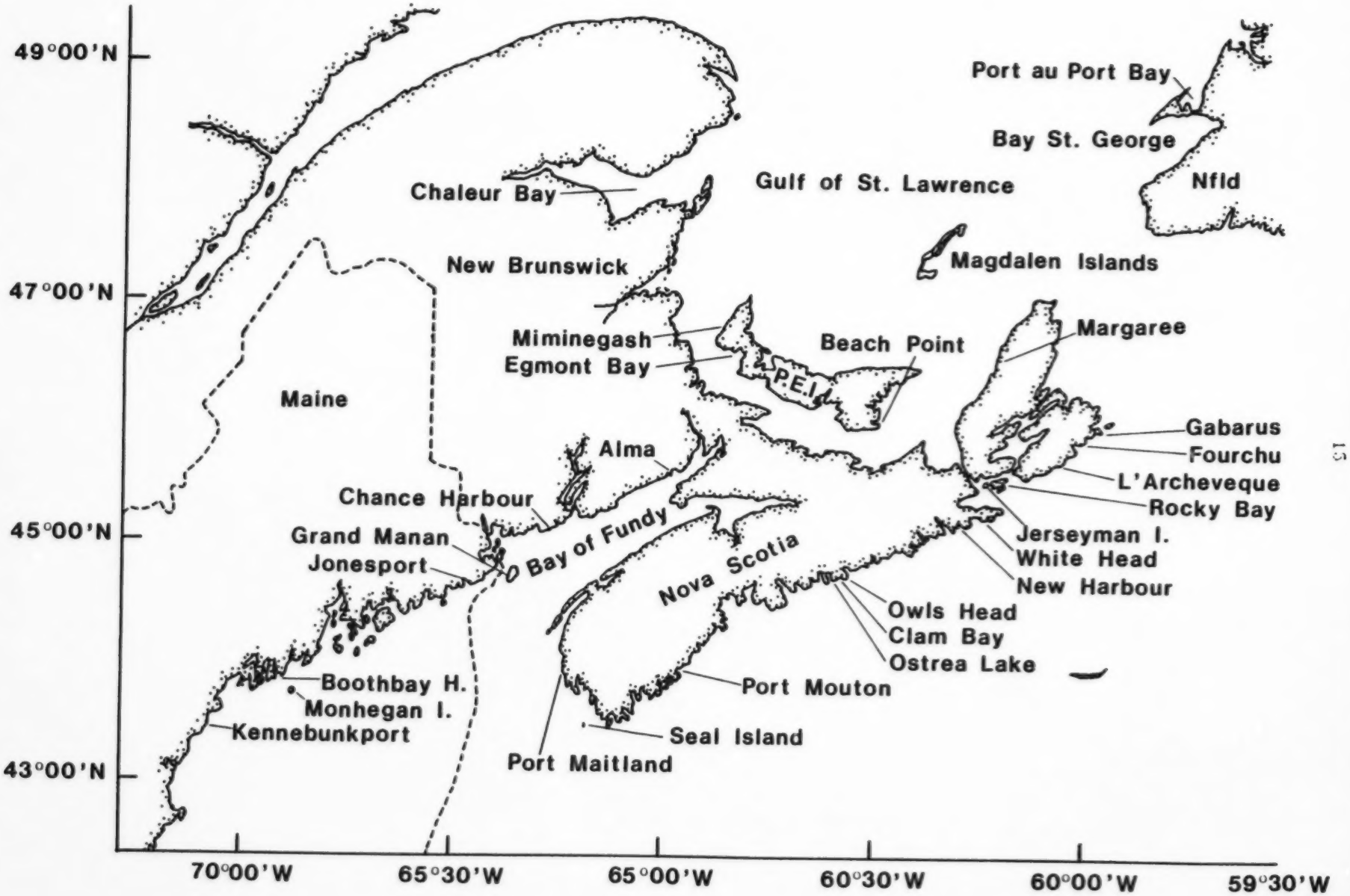
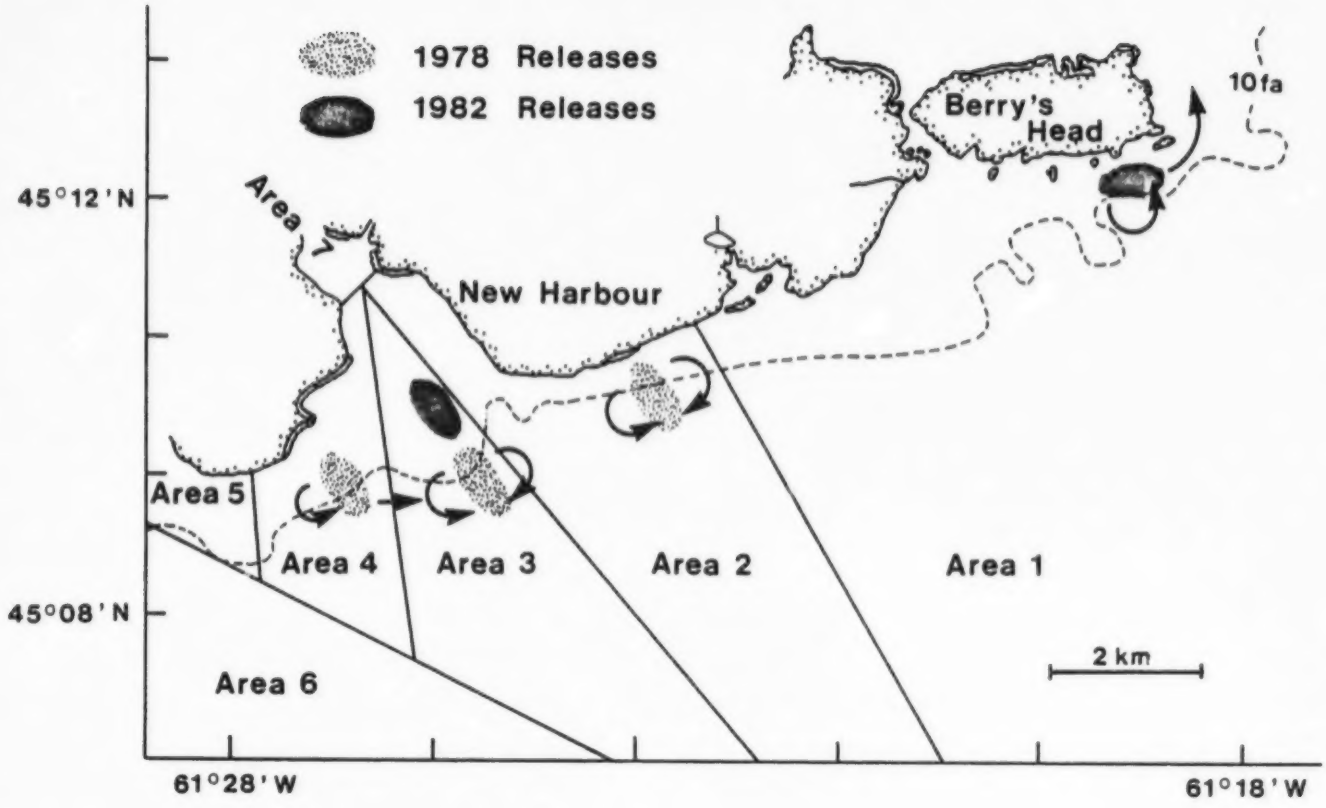


Fig. 1 Location of place names referred to in the text. Placentia Bay and Bonavista Bay are located in eastern Newfoundland and are not shown.



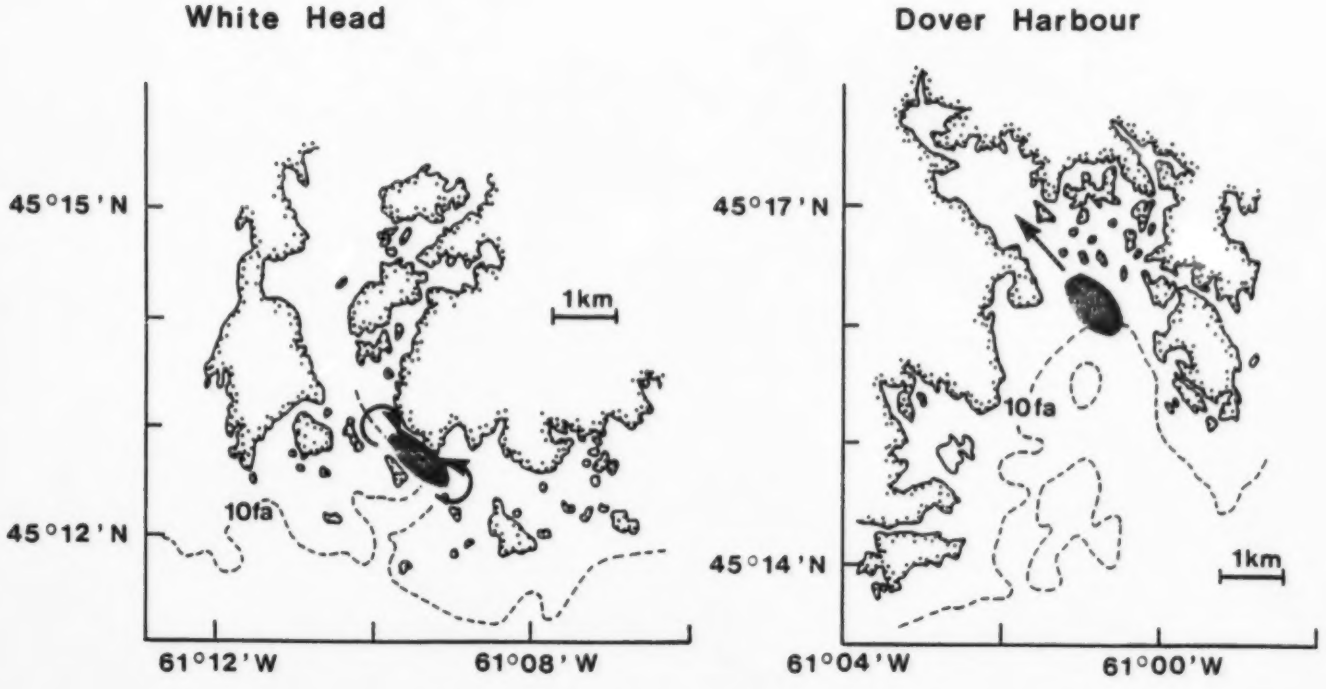


Fig. 2 Release locations of tagged lobsters at New Harbour, Berry's Head, White Head, and Dover Harbour. Arrows point to the locations of most recoveries. Arrows pointing toward the release sites indicate no detectable movement.

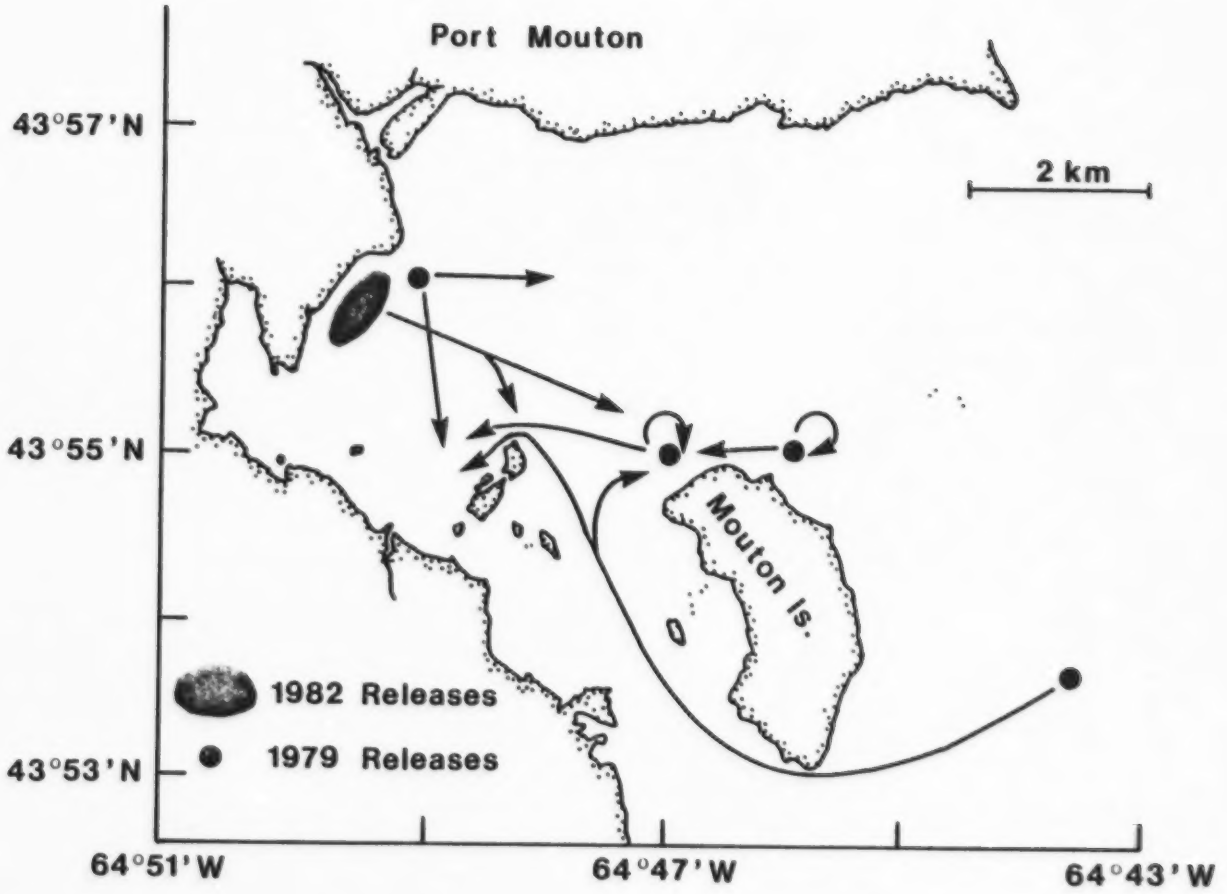


Fig. 3 Release locations of tagged lobsters at Port Mouton. Arrows point toward the locations of most recoveries. Arrows pointing toward the release sites indicate no detectable movement.